RESEARCH, DEVELOPMENT AND APPLICATION OF THE INNOVATIONAL TECHNOLOGY OF HIGH QUALITY PUMP-COMPRESSOR PIPES PRODUCTION FROM SECTIONS*

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Abstract

The innovational technology of high-strength, cold- and corrosion-resistant pump-compressor pipes from sections was developed. It includes the reduction process inside three-high stand of screw rolling before piercing in the «80» pipe-rolling mill line in OAO SinTZ. The special attention is paid to the questions of fine-grained steel production and final tubes quality. It is shown that new technology is efficient from the point of tube production of high level mechanical properties.

The new technology of high-strength pump-compressor pipes production in the «80» pipe-rolling mill line was developed at OAO SinTZ. In order to increase the efficiency of pipe production from sections in that line the three-high stand was installed [1, 2]. At the same time they developed the technology of radial-shear rolling [3, 4]. The change of manufacturing scheme of the pipe production is shown in Fig.1.

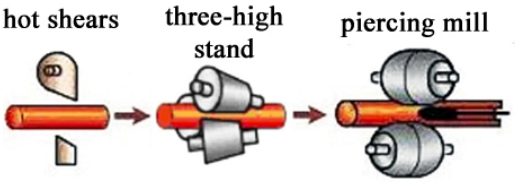
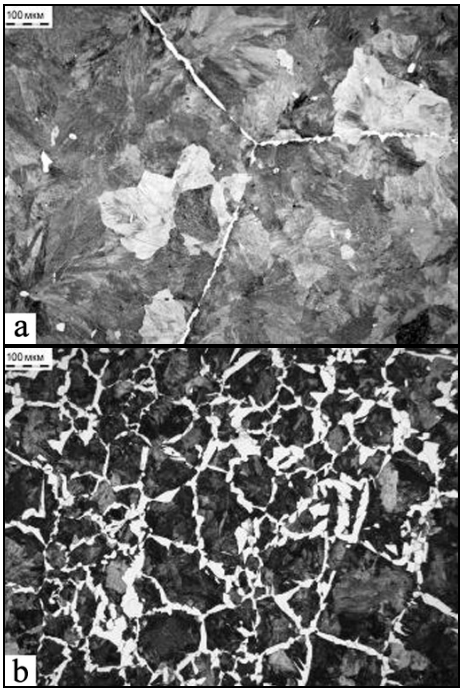


Fig. 1. The change of manufacturing scheme of the pipe production

The advantage of radial-shear rolling is intensive study of the cast structure of metal and the improve of workpiece technological characteristics. However, the development of new technology has faced two main problems: the axial zone of the workpiece kept porosity due to unevenly distributed deformation over the cross section; the cavities are formed on the ends of the workpiece after the radial-shear rolling that leads to separation of semi-rings from the workpiece during piercing.

The researches of rolled billets (diameter 120 mm) and cast sections (diameter 150 mm) microstructure after every step in technological line (they include heating, radial-shear rolling, piercing, rolling-off, reduction and heat treatment) allowed to study steel grain structure transformation from workpiece to final tube. Optical microscope Axiovert 40MAT was used for studying microstructure of the tubes and workpieces from 32HG steel with used of longitudinal metallographic samples. After polishing the samples were subjected to chemical etching in 4%-alcoholic solution of azotic acid.



reduction λ=5.94

Fig. 2. The initial microstructure of cast section (a) and rolled billet (b)

They have come to the conclusion that the application of efficient grooving, angular and radial roll setting, rolling schedule of sections in three-high stand of screw rolling, as well as usage of once heating instead of double one according to the previous technology, leads to reducing of deformation heterogeneity, intensive workup of coarse-grain dendrite structure, decreasing of porosity in the axial zone of cast billets and improving of technological characteristics of the metal. Due to the above mentioned process the dispersion of grain structure was increased, as well as the phase composition of steels after the heat treatment. The grain size of section after the radial-shear rolling (Fig. 3) is smaller than the grain size of rolled billets (Fig. 2b). The initial structure of section is shown in Fig. 2a. The grain size of the final tubes made from sections is 40-70 micrometers, but the grain size of the final tubes made from rolled billets is 100-200 micrometers (Fig. 4). The differences of the structure dispersity shown in the figures 2-4 can be

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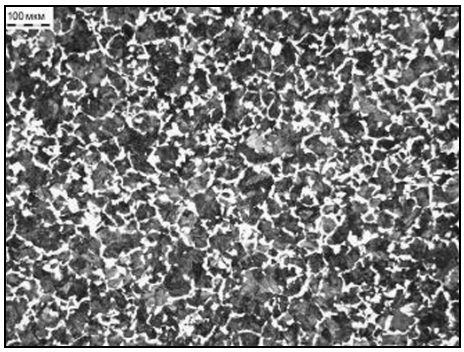
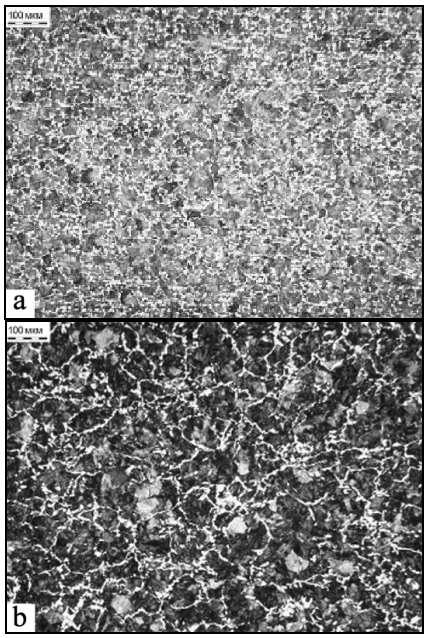
explained by several reasons: difference between technology and modes of out-of-furnace treatment and continuous casting of steel by OAO STZ and OAO NTMK; number of heats, the scheme and modes of blanks deformation prior to the piercing in the «80» pipe-rolling mill.



reduction λ=1.56

Fig. 3. The section microstructure after screw rolling

The histograms of mechanical properties of pipes made from 32HG steel are shown in Fig. 5-8. We can see that dispersion of the mechanical properties of pipes, made according to the new technology, decreased on average by 10% as compared with the dispersion corresponding to the rolled billets. As the result reliability of the required level of mechanical properties of the tubes was increased, production of second quality pipes which mismatch the mechanical properties of the standard requirements was decreased. The mechanical properties of the finished products met the requirements for high-strength pump-compressor pipes. Steel grades of pipes made from sections in the «80» pipe-rolling mill corresponding to the Russian state standard specification 633-80 are shown in Table 1. Application of sections in the new technology provides obtaining high-quality pump-compressor pipes including high-strength, cold-resistant and corrosion-resistant pipes.



total reduction λ=15.15 total reduction λ=57.62

Fig. 4. The microstructure of pipes made from section (a) and from rolled billet (b)

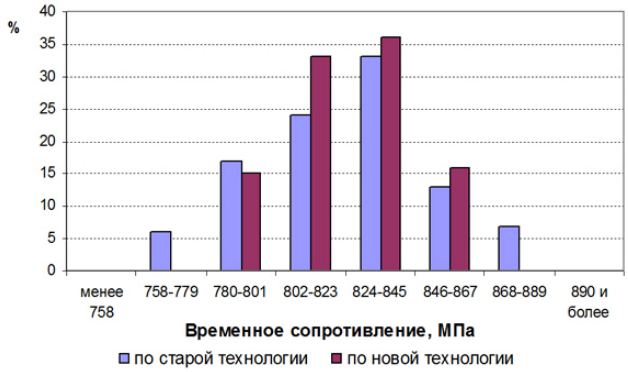


Fig. 5. The histogram of tensile strength of pipes made from 32HG steel in the cold-resistant performance, MPa

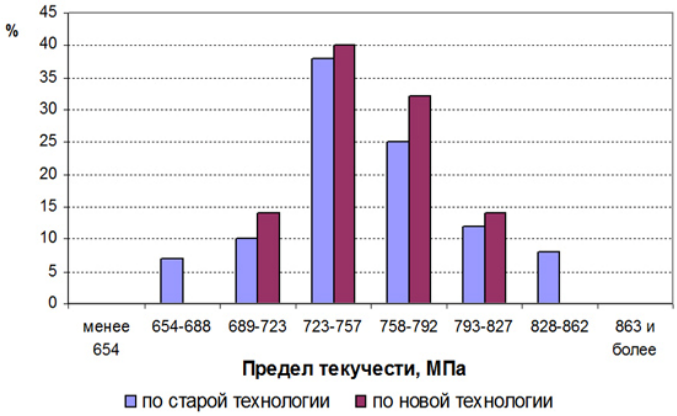


Fig. 6. The histograms of yield stress of pipes made from 32HG steel in the cold-resistant performance, MPa

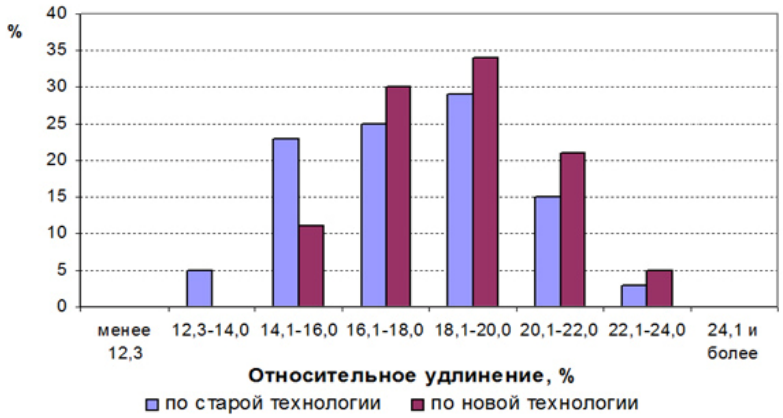


Fig. 7. The histograms of percent elongation of pipes made from 32HG steel in the cold-resistant performance, %

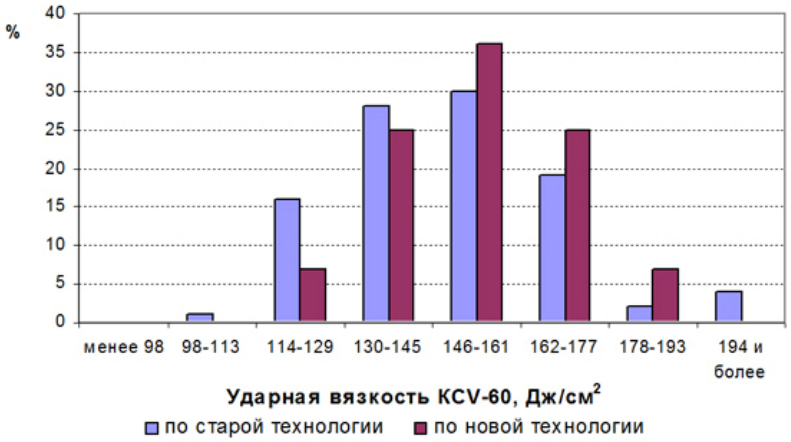


Fig. 8. The histograms of impact elasticity of pipes made from 32HG steel in the cold-resistant performance, J/cm^2

With the development of new technology the problem of increasing the number of pincher defects from 2-3% to 6-7% was appeared. The industrial researches of the new process have shown that it was caused by the formation of cavities in the radial-shear rolling on the rear ends of the workpieces, the formation and separation of semi-rings after piercing (Fig. 9). Modernization of the ways to cut the workpiece on the hot shears was the solution of the problem. Research and development of a new method of cutting process providing profiling of workpiece ends have reduced the number of pincher defects in 2.5-3 times. As a result of physical modeling and mathematical simulation of the cutting process for minimizing the depth of cavities on the workpiece during the radial-shear rolling the optimal shape of knives for cutting was found. The industrial experiments revealed that at a depth of cavities less than 17 mm there was no separation of semi-rings on the rear end of cupped blank and the number of pincher defects didn't exceed 2-3%.

Table 1.

Steel grades of pump-compressor pipes including high-strength, cold-resistant and corrosion-resistant pipes

Type of threaded connection	Size of pipes, mm					
	33x3,5	42x3,5	48x4	60x5	73x5,5	89x6,5
Plain tube	Д,К,Е	Д,К,Е	Д,К,Е,Л	Д,К,Е,Л,М	Д,К,Е,Л,М Ес,Лс	Д,К,Е,Л,М
With the upset ends (НКВ, НКМВ)	–	–	–	Д,К,Е,Л,М	Д,К,Е,Л,М Кс,Ес,Лс	Д,К,Е,Л,М Ес,Лс
With the elongated upset ends (НКВ-У)	–	–	–	–	Д,К,Е,Л,М Дс,Кс,Ес,Лс	–
Plain tube, highly pressurized (НКМ)	–	–	–	Д,К,Е,Л,М	Д,К,Е,Л,М Ес,Лс Ехл,Лхл,Мхл	Д,К,Е,Л,М Ес,Лс

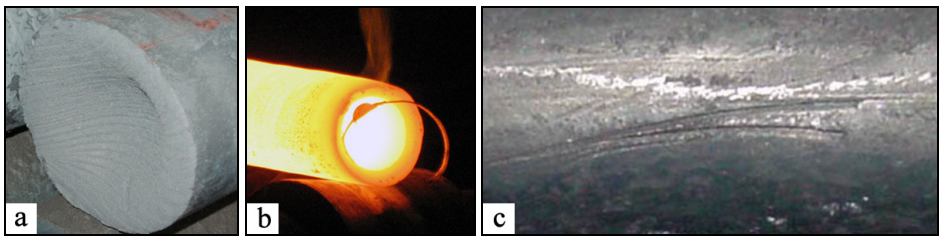


Рис. 9 – Formation of cavity on the workpiece (a), semi-ring on the rear end of cupped blank (b), pincher defect on the outer surface of the pipe (c)

As the result of modernization of the pipe production technology cost of pipes decreased by 10%, productivity increased by 15%, the percentage of good products increasedfrom 98.8% to 99.08%. The usage of sections after screw rolling allowed to improve the piercing conditions, that led to decreasing of nonuniform cupped blank wall thickness an average of 1-2%. The regularities of cavities formation on the outer surface of the pipe have been studied and the technical solutions how to avoid the causes of their formation have been found. It is shown that the section application provides the production of high-strength, cold-resistant and corrosion-resistant pump-compressor pipes.

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